

Layer-Structure-Distribution in the Sample Plane of Mo/Si Multilayers Measured by Total-Electron-Yield X-Ray Standing Wave Methods

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Total-electron-yield (TEY) x-ray standing-wave measurements of multilayer x-ray mirrors have been performed, by monitoring sample photocurrents in BL-6.3.2 to obtain information on their layer/interface structure. Specifically, we have measured mapping spectra of x-ray standing-wave signals in a Mo/Si multilayer at normal incidence, which visibly illustrates the spatial distribution of layer structure in the sample plane.

The Mo/Si multilayer x-ray mirror, deposited on a 4-inch silicon wafer, consists of 50 periods of 19.6-Å Mo and 45.2-Å Si layers. The multilayer x-ray mirror sample is mounted on a sample holder in the reflectometer and a wire is connected to monitor the sample photocurrent. In total electron yield (TEY) x-ray absorption spectral measurements, x-ray standing-wave structure is observed when the photon-energy/wavelength of incident x-rays and the incident angle satisfy the Bragg reflection condition of the multilayer sample.

Figure 1 shows the TEY x-ray standing-wave spectra of a Mo/Si multilayer mirror measured along the 4-inch-wafer-size sample plane at the center (denoted by A in the Figure), middle (Bx, By) and periphery (Cx, Cy) positions. In the center position spectrum, standing-wave structures are observed near 96 eV and the standing-wave peak is observed at 97.68 eV. In the spectra of the middle and periphery positions, standing-wave structures are clearly shifted to higher-energy regions. Figure 2 shows the mapping spectrum of TEY x-ray standing-wave signals over the quarter of the 4-inch-wafer-size Mo/Si multilayer mirror measured with an incident angle of 90°. The photon energy of incident x-rays is fixed at 97.68 eV, identical to the peak energy of the center position x-ray standing-wave. The spot size of incident x-rays on samples is estimated to be less than 0.5 mm^φ, and spectra are obtained using a 1-mm step scan along the x- and y-axes. This figure depicts periodic-length-changes of Mo/Si layers in the sample plane; the Mo/Si layers gradually become shorter from the center toward the periphery. The contour line also reveals a distribution of layer structure that is slightly wider along the y-axis than along the x-axis. This implies the sputtering source gas used in the deposition process of the multilayers is distributed slightly offset from the y-axis. These results indicate that TEY x-ray standing-wave measurements are useful for evaluating the layer/interface structure of multilayer x-ray mirrors.

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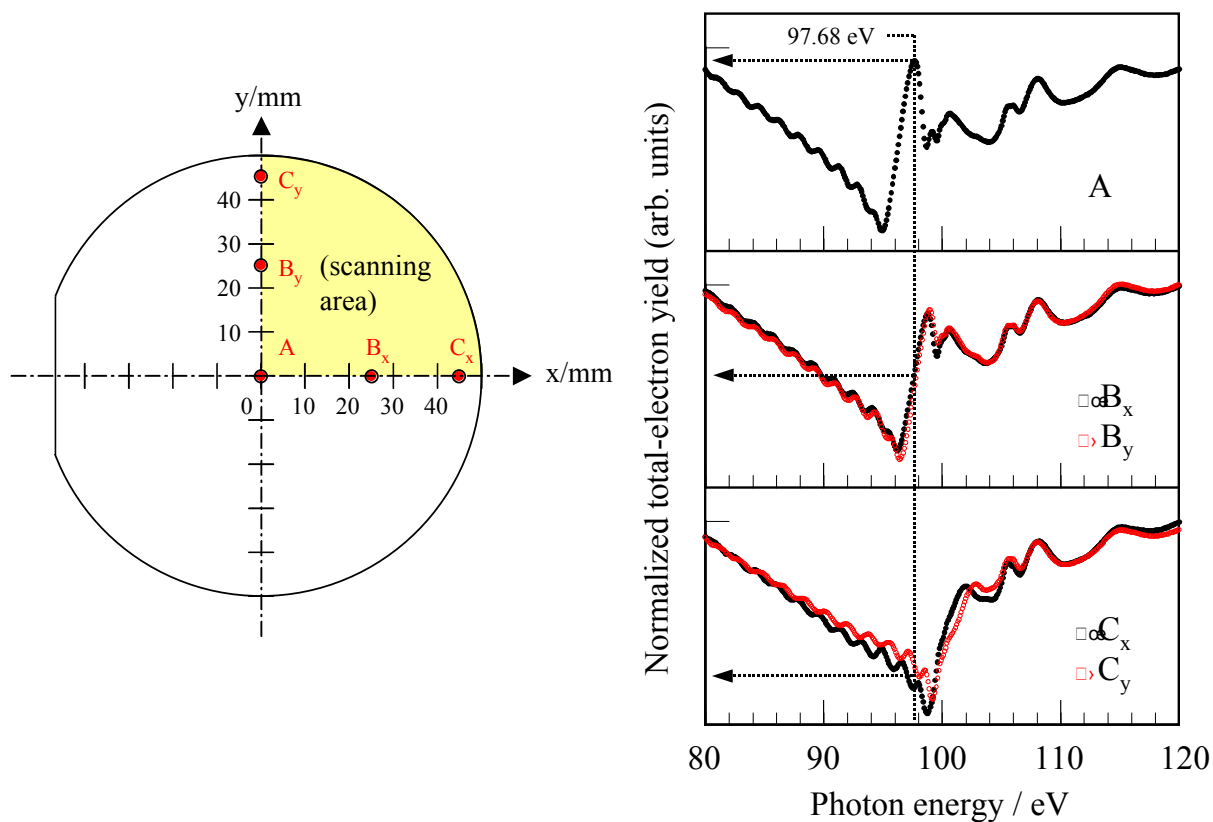


Figure 1 TEY x-ray standing-wave spectra of the Mo/Si multilayer measured at the center (denoted by A), middle (B_x, B_y), and edge (C_x, C_y) positions along the 4-inch sample plane.

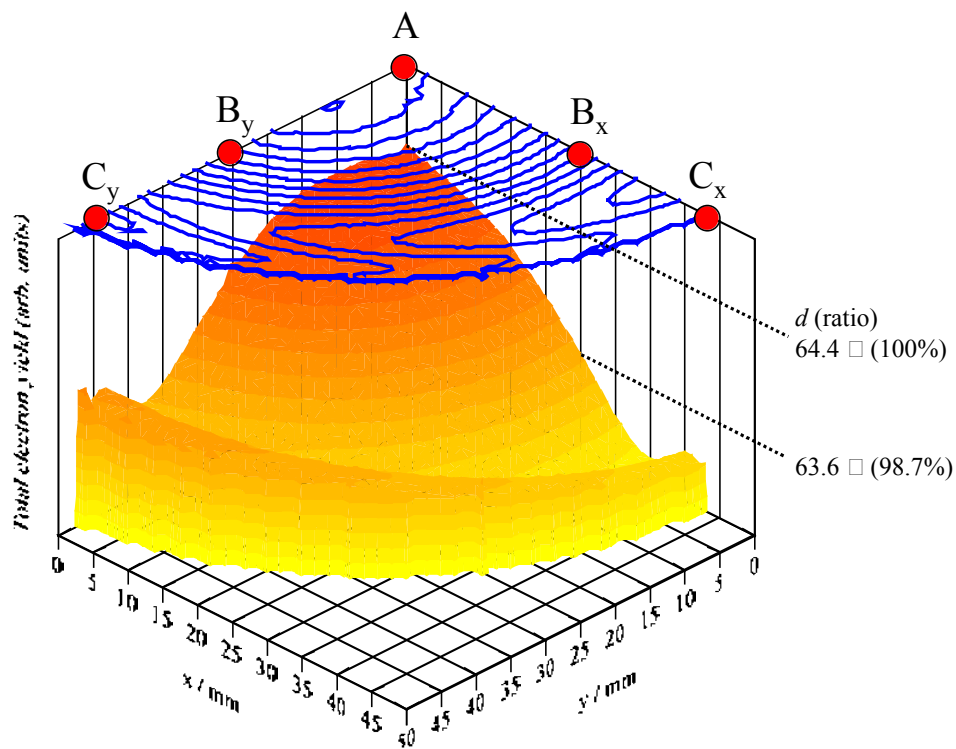


Figure 2 Mapping spectrum of the TEY x-ray standing-wave signals in the quarter of the 4-inch-wafer-size Mo/Si multilayer measured with an incident angle of 90°. The photon energy of incident x-rays is fixed at 97.68 eV.